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AESOP: A GENERAL PURPOSE APPROACH TO REAL-TIME, DIRECT ACCESS MANAGEMENT INFORMATION SYSTEMS

JUNE 1966

J. Spiegel
J. K. Summers
E. M. Bennett

Prepared for
DEPUTY FOR ENGINEERING AND TECHNOLOGY
DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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Project 5050
Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract AF19(628)-5165

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FOREWORD

The contribution of Joyce Wiatroski in the designing and programming of the illustrated management information system of the future is gratefully acknowledged.

This technical documentary report has been reviewed and is approved.

John J. Egan

CHARLES A. LAUSTRUP, Col, USAF
Director of Computers
Deputy for Engineering and Technology

ABSTRACT

AESOP, a laboratory-based prototype of a general purpose, on-line, visually-oriented information system, is used to investigate ways of handling many different types and levels of command and management problems spanning organizational levels from the executive suite down through the staff and operations analysts to the actual system designers and programmers. In particular, it deals with those organizational activities that require highly flexible, direct-access capabilities.

The system is configured for easy use by the inexperienced as well as by the sophisticated, and utilizes a variety of user station devices to facilitate such flexibility, including a cathode-ray-tube display, a lightgun, a typewriter, and associated push-buttons. At each station, it is capable of generating, editing, and formatting information on-line, as well as building, executing, and debugging on-line the analytic and mathematical procedures and algorithms of both the users and the system itself, depending upon the organizational area or level of the user. Although the basic prototype system was developed for use in military command and management planning and information systems, its philosophy and concepts are applicable to industrial and academic organizations.

AESOP: A General Purpose Approach to Real-Time Direct Access Management Information Systems*

Electronic data processing has made available to organizational management vast resources of timely, accurate, and current data. It has given them the support of powerful and rapid computational facilities capable of manipulating such data for wide varieties of managerial purposes. However, techniques for the managerial use of this electronic capacity for data storage and retrieval, or this capacity for the analysis of complex operational models, are only in their infancy. The future of computer-aided management is reflected not so much in the past utilization of data processing by industrial organizations as it is reflected in the military utilization of complex data processing. The United States Air Force recognized, at the start of the computer revolution over a decade ago, that the full power of central processing and central memory was most useful only when that power was delivered in real-time to the desks of the users of the system.

When the power of direct-accessing techniques is realized in industrial organizations, we can look forward to the same radical innovation and reorganization of organizational life and operational behavior that military command experienced earlier. An indication of future information systems that might be used for on-line interactive computer management can be obtained if we start with our knowledge of the remote station techniques for directly accessing central

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* This paper was presented at the American Management Association meeting in New York, February 1966.

processors and central memory on a time-shared basis within operating military environments,* and with capabilities such as those of the AESOP Prototype now operating at The MITRE Corporation. Extrapolation from these can yield some small glimpses into what will become the new world of organizations.

It is well not to forget that the vast superiority of telephone communication over telegraphic communication in today's day-to-day management activities stems not from the fact that one or the other is more conducive to central switching, to dialing, to long-lines transmission, or similar central system activities, but rather from the fact that the technology of the direct-access telephone handset makes it possible for anyone to use the power of the central communications system with personal ease and efficiency. In much the same sense, the power of tomorrow's time-shared, on-line, direct-access data processing will not come when the keyboard of the computer console is placed alongside the desk of thc manager. It will come when the tools of the on-line manager can be placed on his desk, as easy for him to use as his telephone, and will bring all of the power of the system to him on his own unique terms. If a time-shared direct access system terminates in a multiplicity of teletypes or typewriter keyboards, the system then becomes a direct access system for programmers, for scientists and engineers, or for clerks or other classes of personnel willing and able to communicate with the central processor through such devices.

For senior management, however, the mechanism of communication with the processing system must be far more capable of doing what the telephone does for him now. It must permit him to interact with the processor without having to learn a new language or code, without having to know how to type,

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*For example, the North American Air Defense Command.

without having to wait until the processor noisily hammers out its message to him one printed character after another. The typewriters, teletypes, and even the vast arrays of pushbuttons that so often accompany current and popular impressions of direct access management systems are still of much value, but only in the hands of the skilled technicians whose jobs require their special capabilities.

Let us start our look at the AESOP-like management system of the future at the desk of the manager of the future. * The manager of the future has on his desk, in addition to his telephone, a small cathode-ray-tube display, much like a small TV set, capable of generating strings of alphanumeric characters, maps, charts, graphs, and many of the other normal visual records which managers now are accustomed to experiencing by means of reports, documents, letters, memoranda, and similar paper products.

Each display in the AESOP Prototype consists of a page of a file resembling a notebook where each page has 30 lines numbered consecutively and there are as many pages as there are such sets of 30 lines. Each display has a set of columns that are referred to as a section of a file. There are as many sections as there are sets of columns. The user's selection of a specific page and section of a file specifies a subset of lines and columns. Customarily, but not necessarily, lines identify objects, columns identify properties, as shown in Figure 1.

The user's notebook contains as many files as are required to hold the organization's data base, and also an arbitrary number of files with completely

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* Keep in mind, however, that everything discussed below exists today either in the military or in the laboratory, and represents nothing more than current technology.

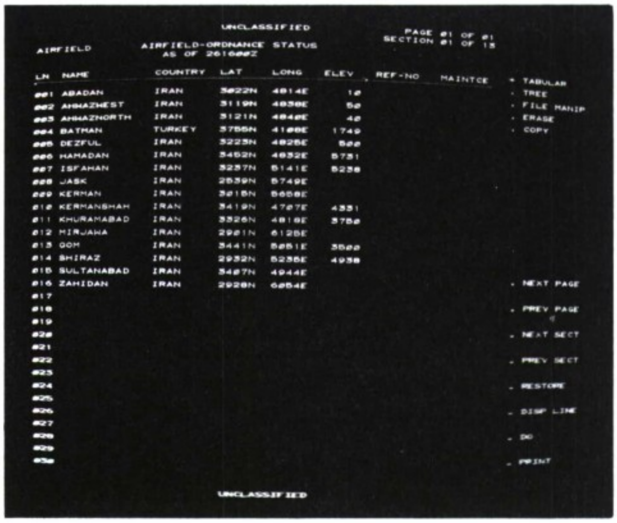


Figure 1. Page 1 Section 1 of a File Dealing with Airfields

blank pages that serve as the environment within the notebook in which the individual user builds his private data base and personal report formats.

In addition to this relatively standard capability, there is his lightgun. The lightgun is a small photoelectric device capable of sensing any of the signals appearing on the desk top display whenever it is simply pointed at the location of that signal. The signal is then referenced back to the central processor in order to indicate the user's intention or desires. By pointing to critical elements on the display, the user has a relatively simple and reliable mechanism for communication and interaction with the processor. If the user of the lightgun wants the computer to perform some action, he merely points this pointer at the appropriate command displayed to him on the display, and the computer will operate accordingly. Figure 2a shows a displayed portion of a file — in this case page 1 section 1 of a file dealing with Visitors. Figure 2b shows that same file with the lightgun firing on one of the side commands, NEXT PAGE. Figure 2c shows the same file but now with page 2, section 1 displayed. In the same manner, one can communicate to the processor desires for other changes.

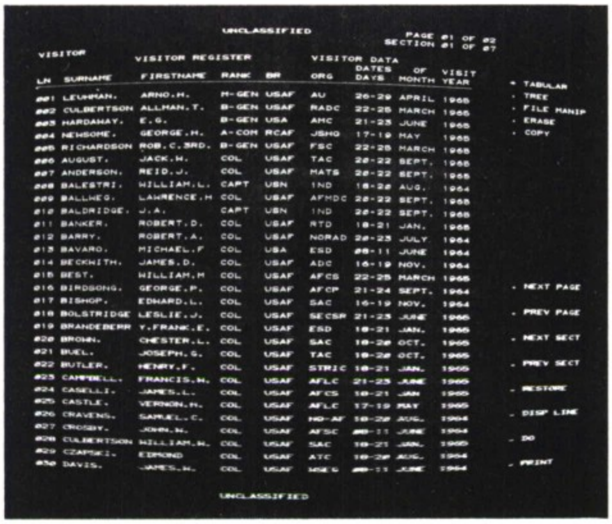


Figure 2a. Page 1 Section 1 of a File Dealing with Visitors

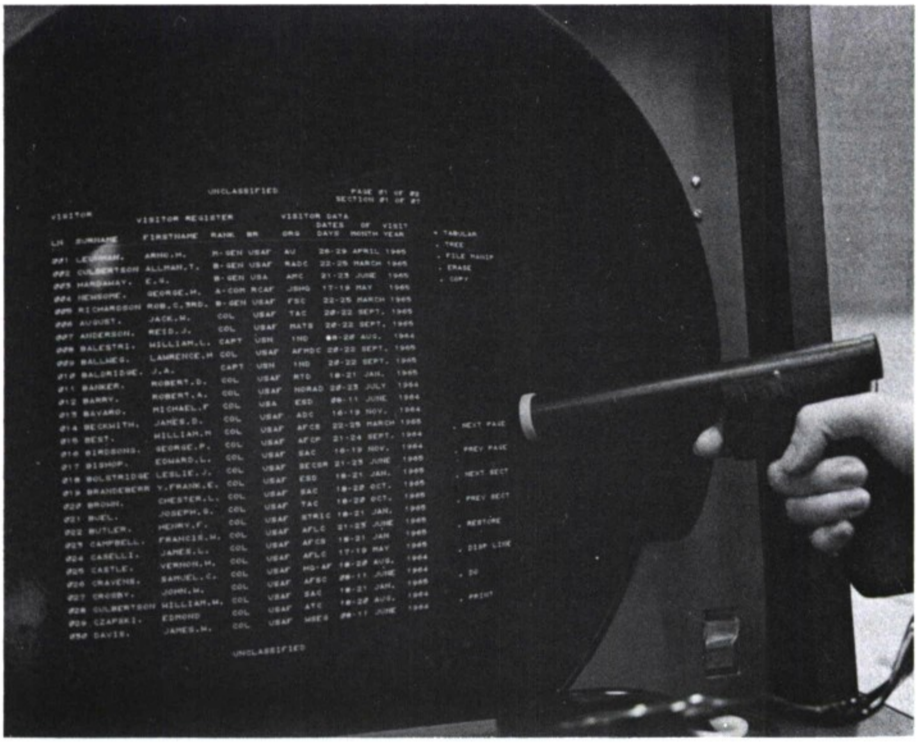


Figure 2b. Lightgun Firing on Marginal Command NEXT PAGE

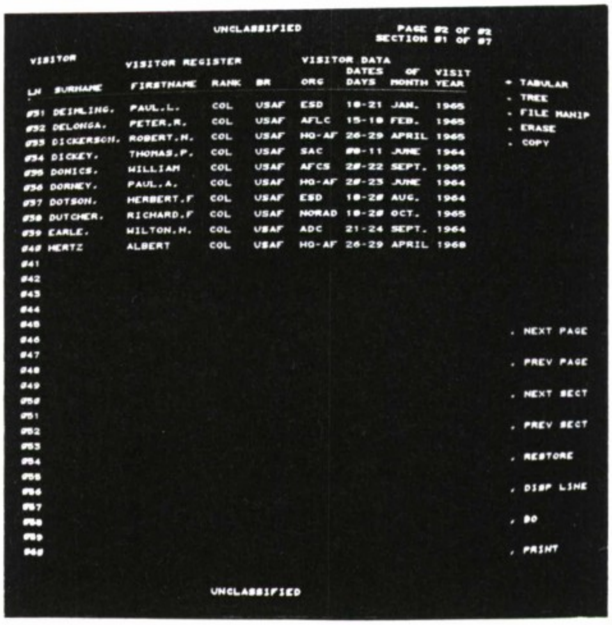


Figure 2c. Page 2 Section 1 of The Visitor File

When the processor has a question, the acceptable set of responses to that question may be displayed to the viewer at his desk, and he, in turn, may indicate his response by pointing out the correct alternative. If he wishes to add messages or data to either a public file or his own private files, he may do so through the use of the simple pointer, pointing his way to a display of letters or words in sequence and thereby building his message. However, in no case should he have to remember the syntax or index necessary for using the system. Communicating with a computer via a prescribed language can present a training problem when there are many users of the computer. To improve this situation in AESOP we have taken the syntax of the primary subset of the input language and presented it to the user on the display scope in the form of a tree. This tree structure allows an operator to see the legal forms of an input message by going down one of the various paths or limbs of the tree. A copy of this syntax tree is shown in Figure 3. If the communication is more extensive, the manager can always ask his secretary to enter his message by

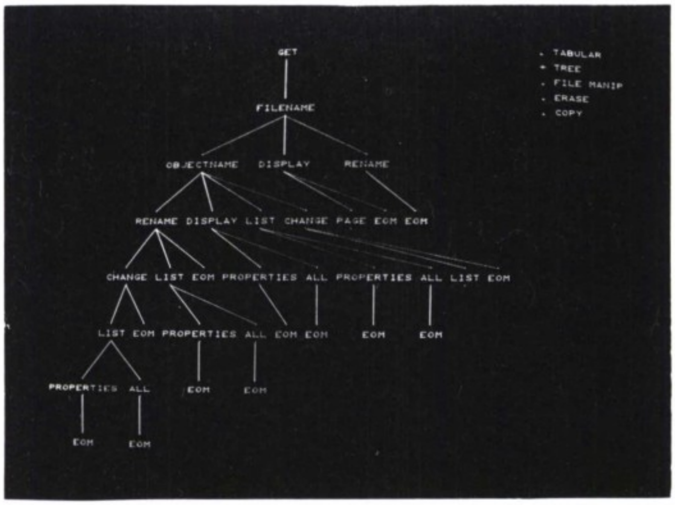


Figure 3. The Basic AESOP Communication Tree

means of the typewriter, which functions not only for her own normal secretarial duties, but also as an on-line access mechanism. She can then use this conventional tool for generating queries, messages, or similar communications to the machine and through the machine to other members of the organization.

The corc of the management system of the future will be not so much the central processor or central memory, or even a time-shared executive, which makes these equally available to all users. The real basis of the system will be the unique program of instructions which makes the central processor, the central memory, and the organization's store of data and formal quantitative models easily available to the manager through the window of his desk top display, thus making it possible for him to exert the full power of his intentions through the use of his simple lightgun pointer. As AESOP-type management systems are developed, managers will learn to converse and interact with the processor with ease and naturalness. They will also learn to communicate through the processor with other members of the organization.

Let us now look at the way in which some of the more conventional activities of today's world might be performed in the world of the future. Imagine an executive arriving at his office in the morning and sitting down behind his desk. On his desk is a small cathode ray tube display and a lightgun that he uses to interact with his system. Like all managers, the first thing he does is to call up a display showing his appointment schedule for the day. The first display he sees is shown in Figure 4a. It gives the schedule for the first working day of the month. As indicated in Figure 4b, he turns the page in his schedule to get to the schedule for the day in question, January 4. Having examined his calendar, he notes that he has a conference for 11:00 a. m. and it is scheduled to carry through lunch. He further notes that the discussion is going to deal with a specific corporate project. The name of the visitor, Colonel Hertz, strikes a familiar bell to the executive but he cannot quite place the exact context of his remembrance. He, therefore, asks the system for a retrieval from the organization's background files on visitors and other very important people. This file might be one containing information concerning the individual's organization and position, the dates of any past visits, and other significant corporate intelligence necessary to facilitate dealing with the visitor. However, rather than accessing this file directly by himself, the executive may ask his secretary to do it for him.

The secretary may elect to use her typewriter, as shown in Figure 5a. The computer responds to her typed command by displaying the job title, organization, visit dates, and purpose of his past visits, as shown in Figure 5b. While examining this display the manager may note that a particular project leader has been responsible for the previous contacts with this visitor. He then requests from that project leader a complete briefing on the status of the project in question prior to the arrival of the visitor. In order to do so he simply instructs his secretary to send a memo to the project leader with copies to all

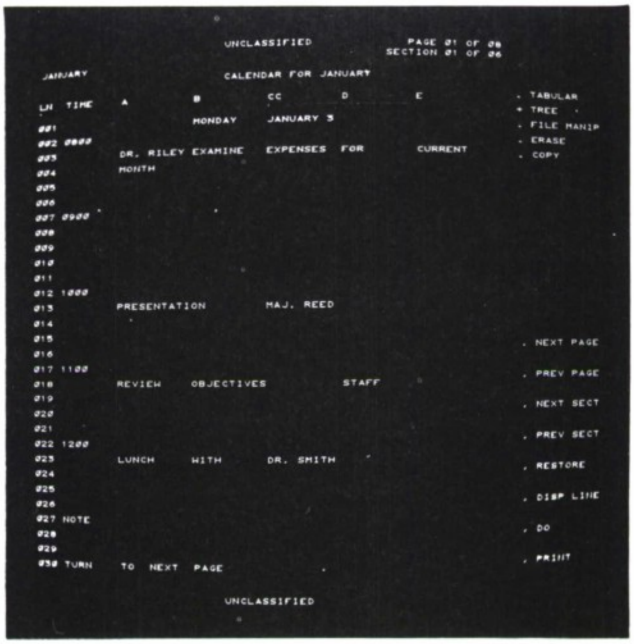


Figure 4a. Page 1 Section 1 of The January File

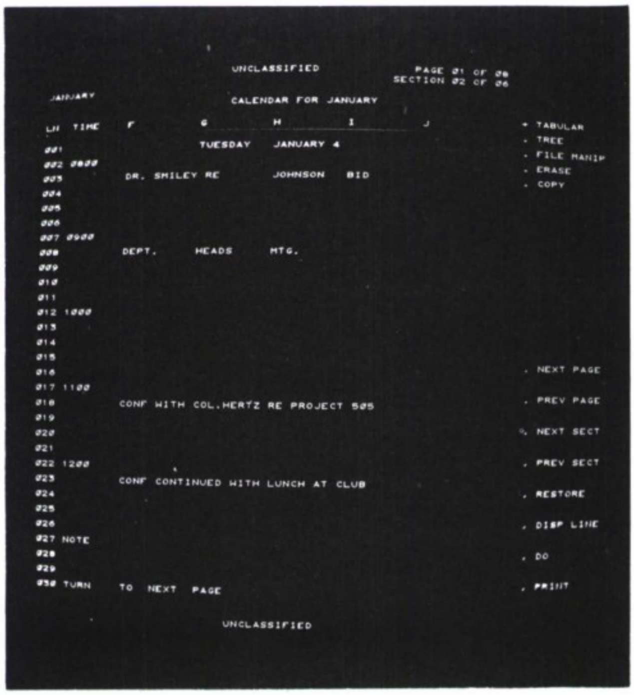


Figure 4b. Page 1 Section 2 of The January File

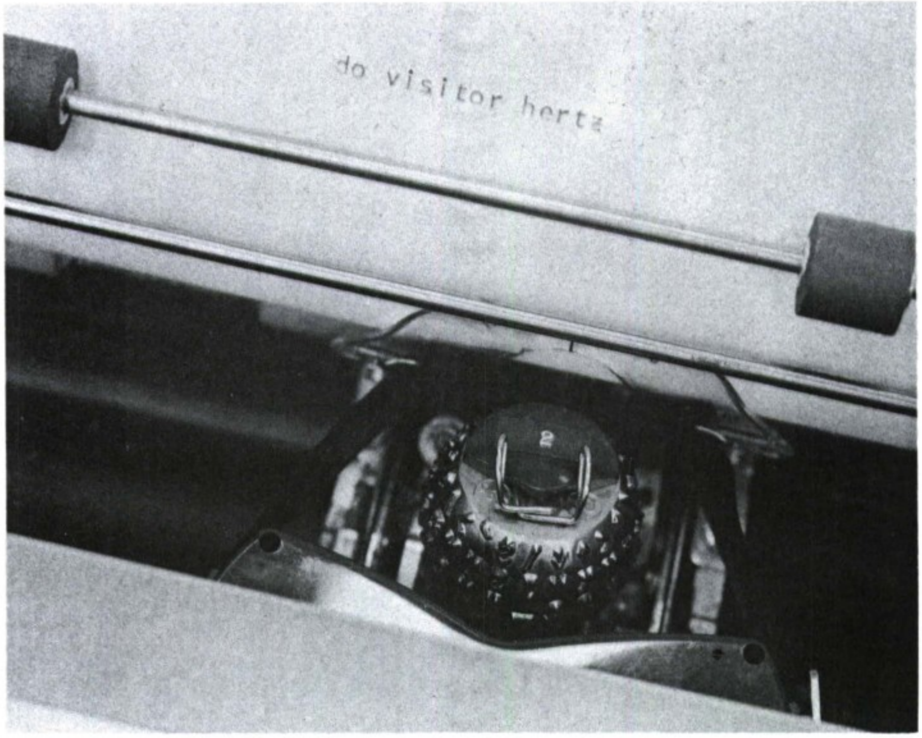


Figure 5a. Typewriter Input Requesting Visitor Information

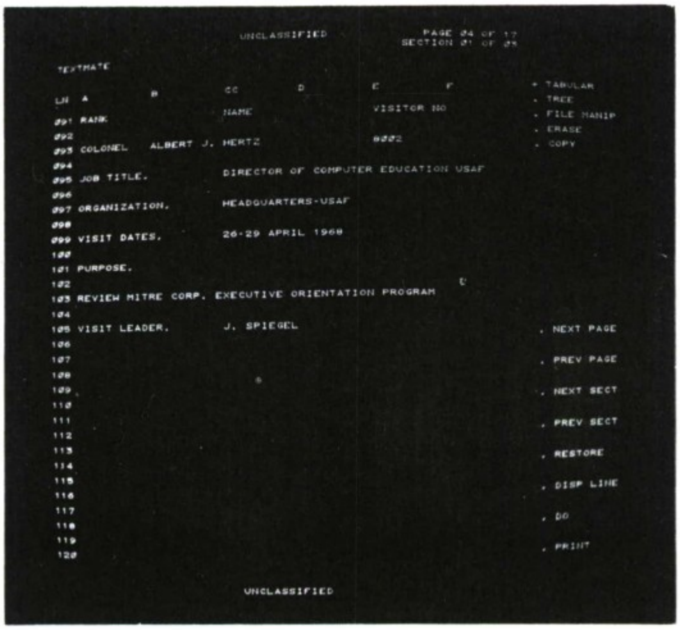


Figure 5b. Visitor Index Card

interested parties telling him that he wants to see him and that he wants to find out more about the visitor and about the project in question. The secretary then indicates to the processor that she wishes to construct an interoffice memo, as illustrated in Figure 6a.

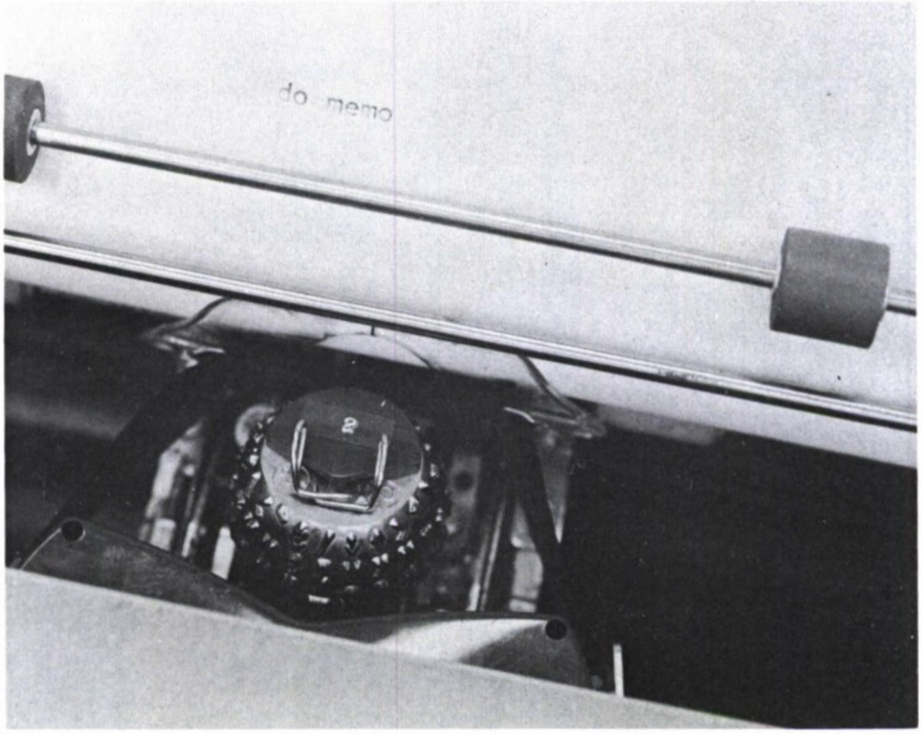


Figure 6a. Typewriter Input Requesting Interoffice Memo Processing

The computer responds to her by giving her the blank form shown in Figure 6b, which she then proceeds to fill in. When it is finished, as in Figure 6c, she may then show it to the manager for his approval prior to transmittal. To transmit this memo to the project leader is nothing more than transferring the message from the file in which the message was constructed to the file that constitutes the electronic in-basket of the particular project leader. At the same

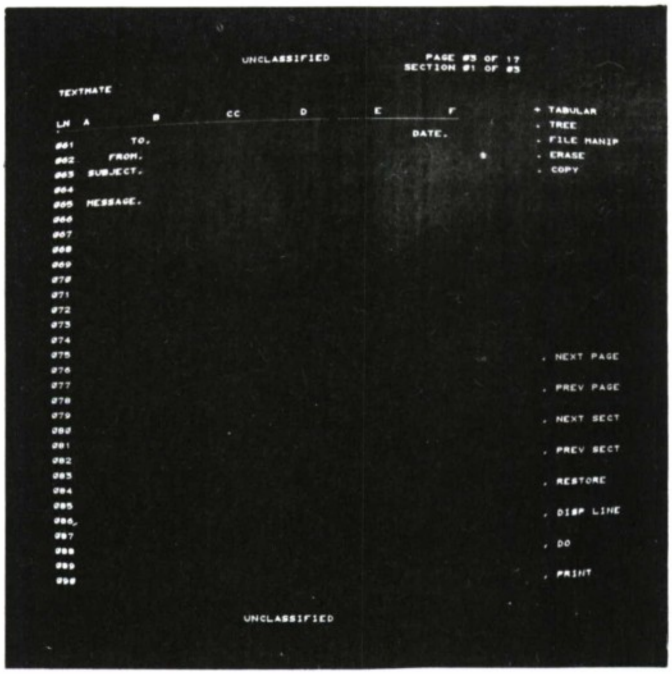


Figure 6b. Blank Interoffice Memo Form

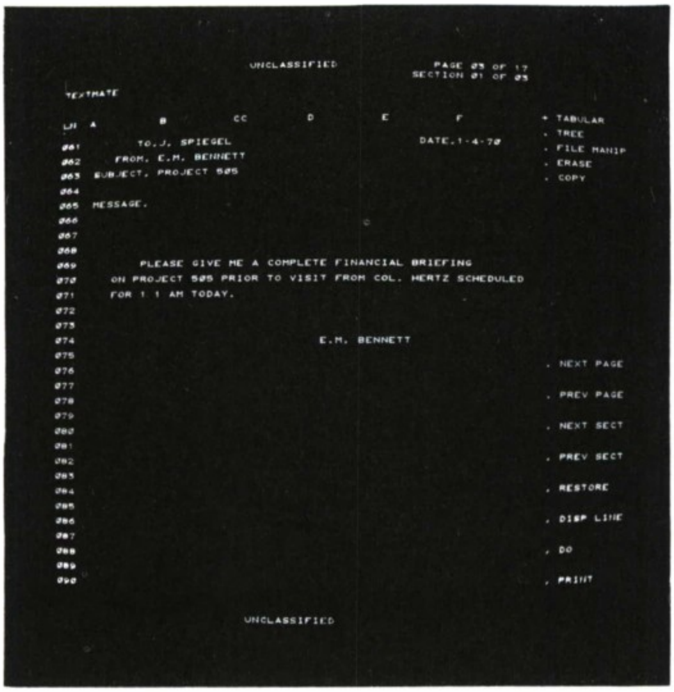


Figure 6c. Completed Interoffice Memo

time that she does this, the secretary may also enter the project leader's appointment with the manager in the manager's electronic appointment book.

Now let us turn our attention to the project leader's desk. He may be using his display to do project scheduling, forecasting or other activities until the priority instruction of his supervisor forces the message to his display. Figure 7a shows his empty electronic in-basket which is soon filled by the priority interoffice memo, as in Figure 7b. As a result of reading the message, he undertakes to prepare the review requested by his manager by calling up various status displays and ending up with the budgetary report shown in Figure 8a. Once again we see that the normal record and paper products of management life appear on this display in a form not very different from the way that it probably would be typed on paper today. In fact, one might well view a display data base as many vast notebooks, handbooks, and files of records available whenever needed and to whomever the organization allows to see the information. In fact, many of today's files that are now maintained on paper are also maintained in the computer.

To continue with our story, the project leader, having reviewed the budget figures, will use his lightgun to copy certain portions of the records into what can be called an electronic vu-graph. The copy message superimposed on the budget display is shown in Figure 8b. After indicating what he wishes to copy into the vu-graph file (Figure 8c) he switches to the vu-graph file and indicates where he wants the information to go, as shown in Figure 8d. The information is then transferred as shown in Figure 8e. This vu-graph file can then be called up later when he wishes to brief his manager. In glancing over this particular vu-graph, the project leader recognizes that line 19 has no data on it and so he erases it as shown in Figures 9a, 9b, 9c, and 9d.

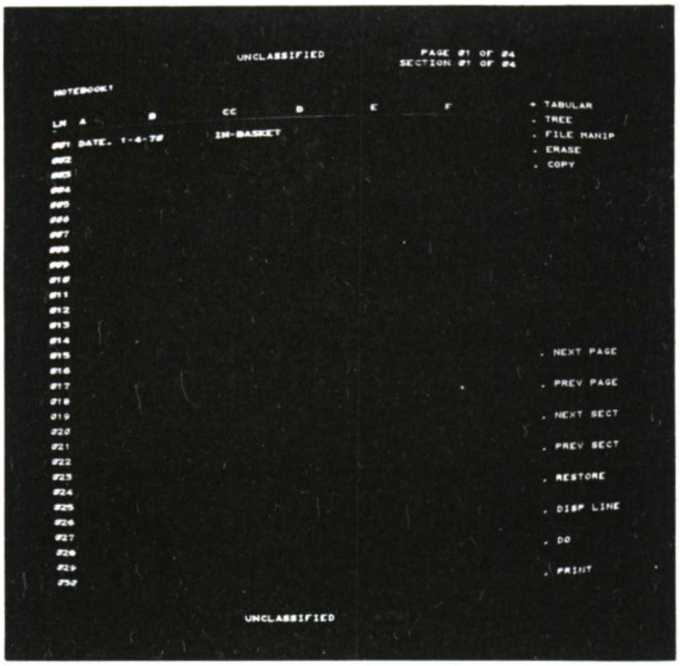


Figure 7a. AESOP Version of Executive In-Basket

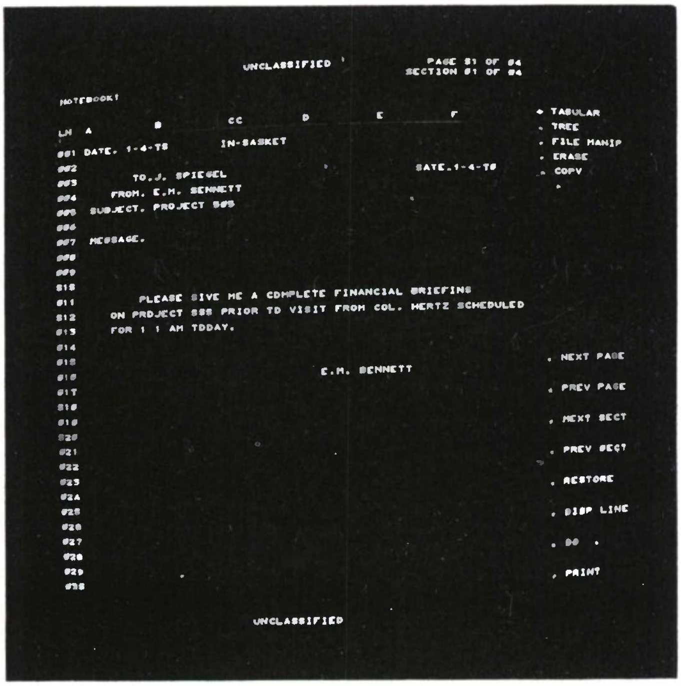


Figure 7b. AESOP In-Basket With Interoffice Memo

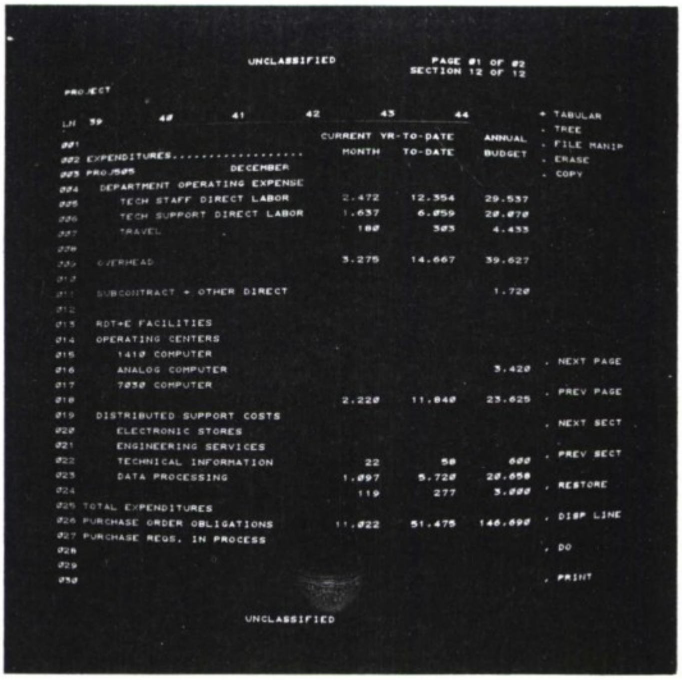


Figure 8a. Budget Report

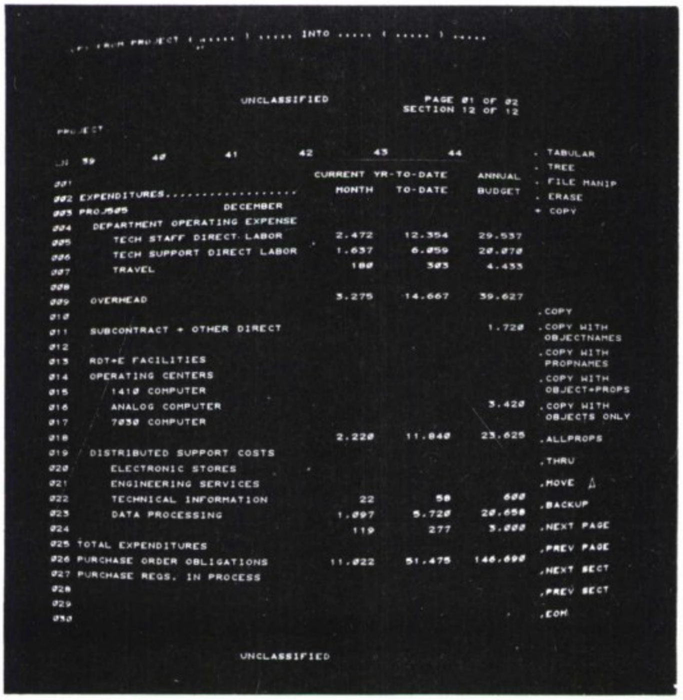


Figure 8b. Skeleton Message to Allow On-Line Data Manipulation Via Lightgun

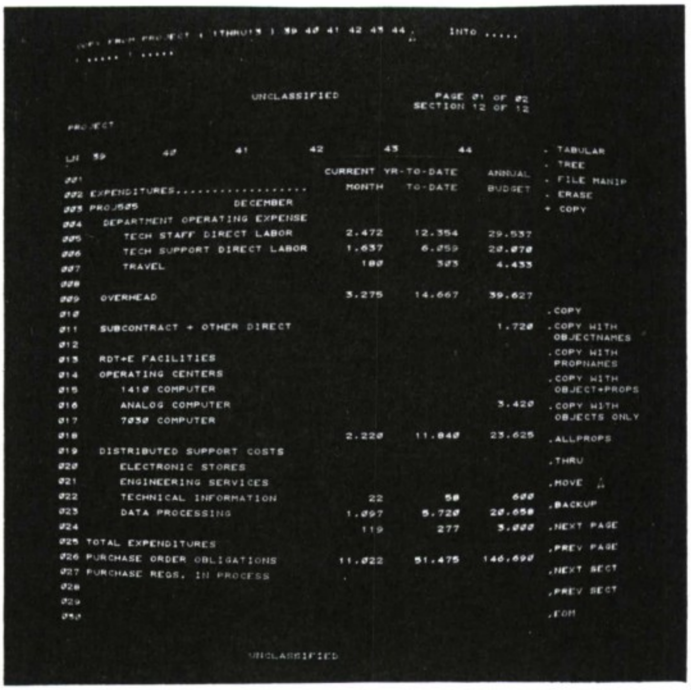


Figure 8c. Skeleton Message With Partially Completed Parameter Insertion for Copy Message

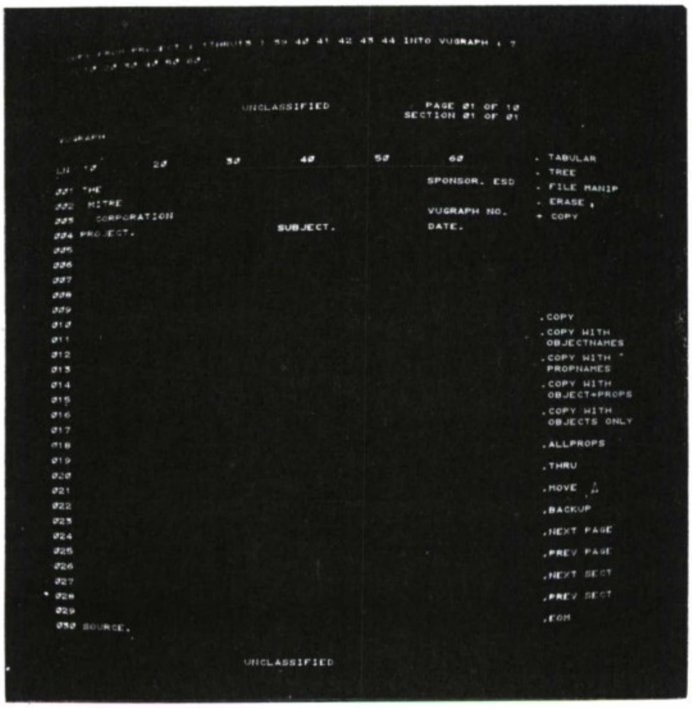


Figure 8d. Completed Message for Copy Instruction

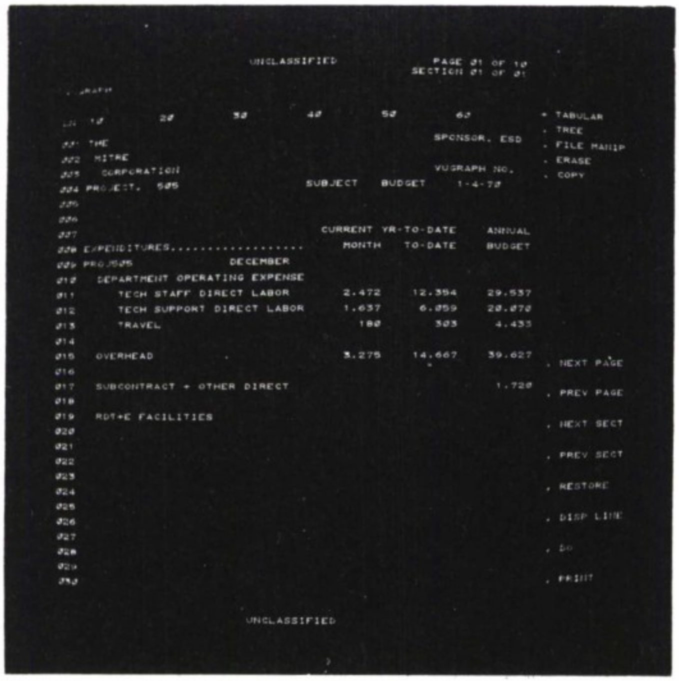


Figure 8e. Result of Copy Instruction

In much the same way any number of vu-graphs can be prepared, edited and re-formatted on-line, until they are exactly as he may want them.

This has been a very brief introduction into the future world of the manager, in which electronic information displays have started to replace paper as the primary vehicle for organizational life. Of course, this is not really all there is to the management system of the future. As we will see, much of the power of such a system lies in its ability to give a manager direct access to forecasting devices, scheduling tools, and other quantitative methods of modern management which, at the present time, must and can be accessed only through specialists and the intervention of operations analysts and programmers.

An AESOP-like on-line management system must operate for the benefit of many members of an organization. There must be capabilities suitable for use by higher level executives, and at the same time, there must be capabilities

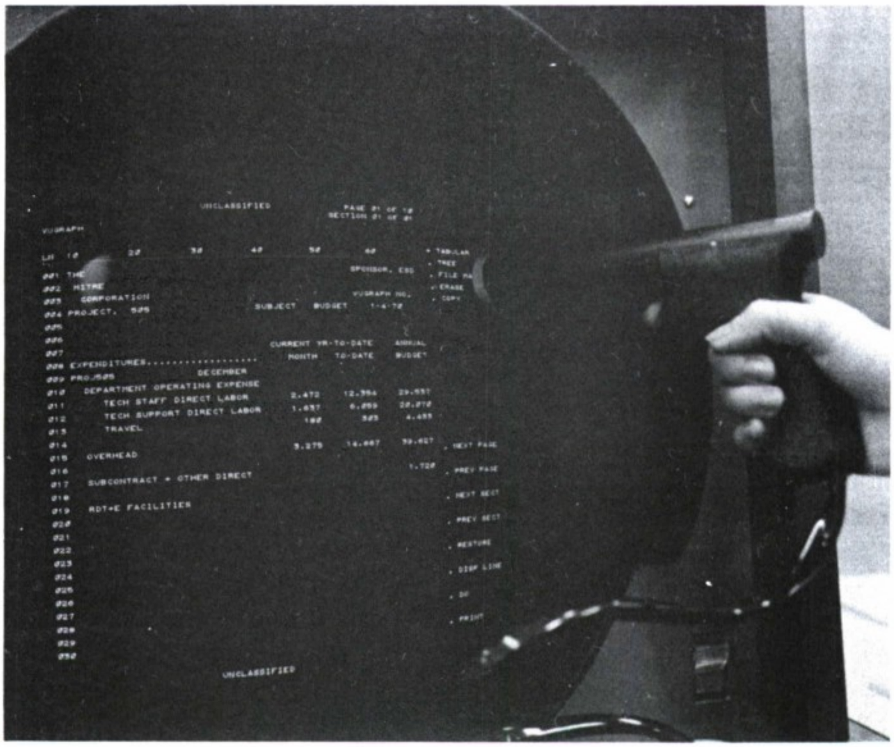


Figure 9a. Lightgun Firing on Marginal Command, ERASE

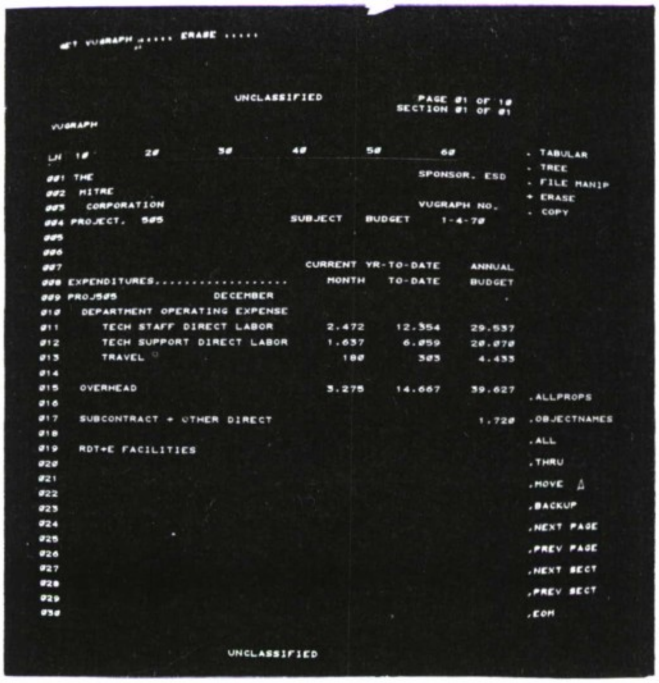


Figure 9b. Skeleton Message to Allow On-Line Data Manipulation

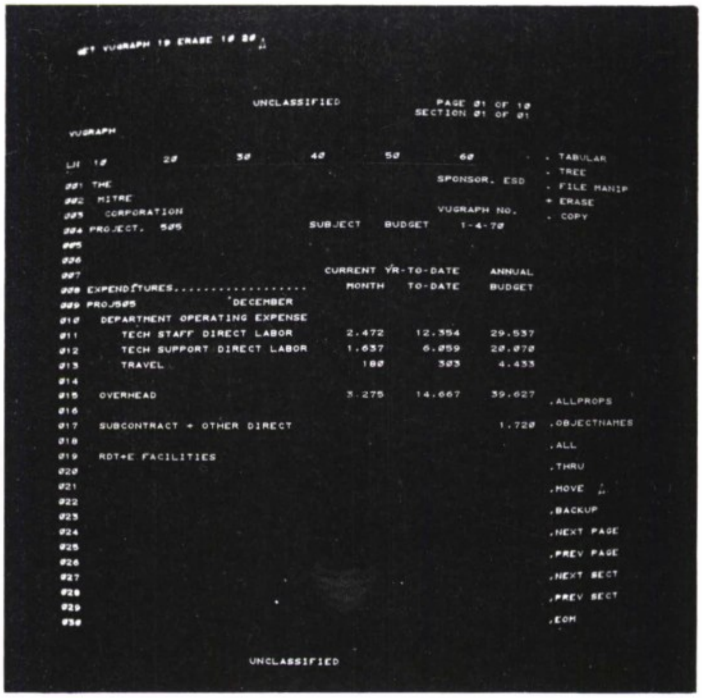


Figure 9c. Completed Message Specifying Line and Columns To Be Erased

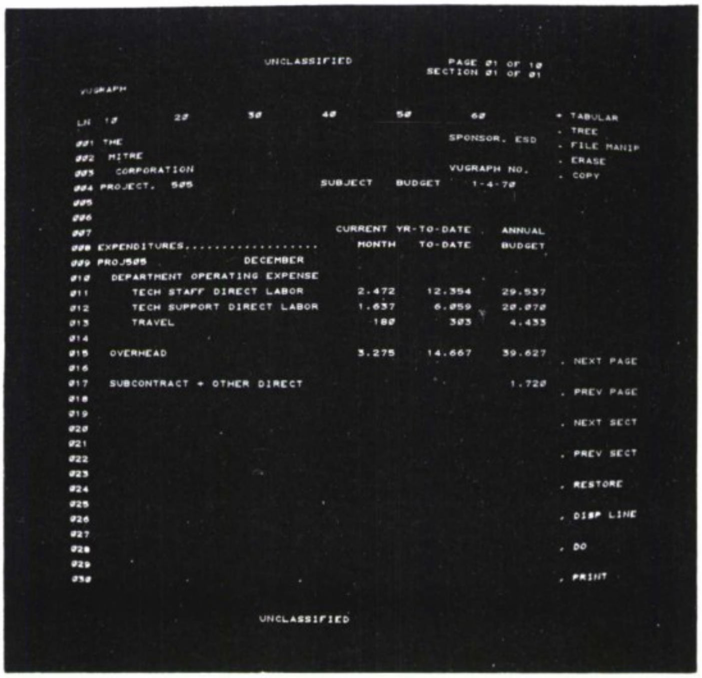


Figure 9d. Result of Erase Instruction

suitable for use by others, equally valuable, to support the forward movement of the system design engineers and system programmers who have responsibility for development, maintenance, and improvement of the system capability.

For the higher level executives, the exercising of algorithms built by his staff of operations analysts can be in the mode of parameter insertion that allows him to call up specific routines requiring only the input of key values. To illustrate this management technique, we have chosen a military example where the problem is to determine the availability of aircraft at up to three bases for assignment to a specific target area. Figure 10a shows the work file in which input data has been loaded for use by the routine. The second section of this same file is reserved for the answer as shown in Figure 10b. A list of routines can be called up and from them we will select one called STATUS1 as shown in Figure 10c. STATUS1 tells us how many aircraft are available at what squadrons, from what bases, what the distance is to the target area, and what the one-way flying time is. The parameters for this routine are the line numbers from which the input data is to be taken and the line numbers on which the output data is to go. Once we have filled in the parameters for this routine to operate as shown in Figure 10d, we lightgun the word EVALUATE and examine the data that this routine has generated. The results are given in Figure 10e.

However, this simple kind of parameter insertion is not enough. The management system must also be able to support the work of the operations analysts and functional area experts whose analyses and quantitative methods constitute much of the power and capability of the system itself. These analyses and quantitative methods require an algorithm-building or construction capability. This too, is part of the present AESOP prototype system.

To illustrate how we make use of this capability, we will now set up a simple multiplication. To do this, we call up the same display shown in Figure 10c.

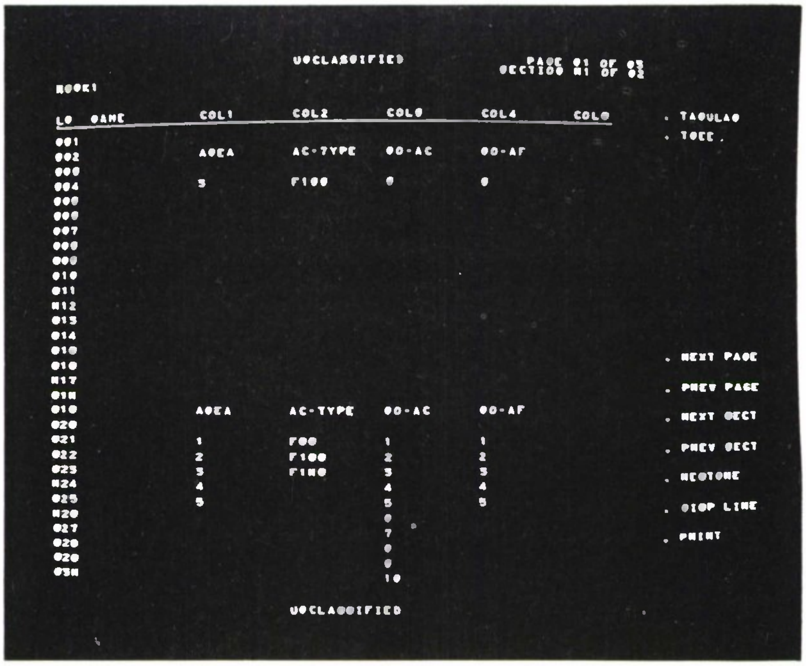


Figure 10a. Page 1 Section 1 of Work File Loaded With Data To Be Used By Routine

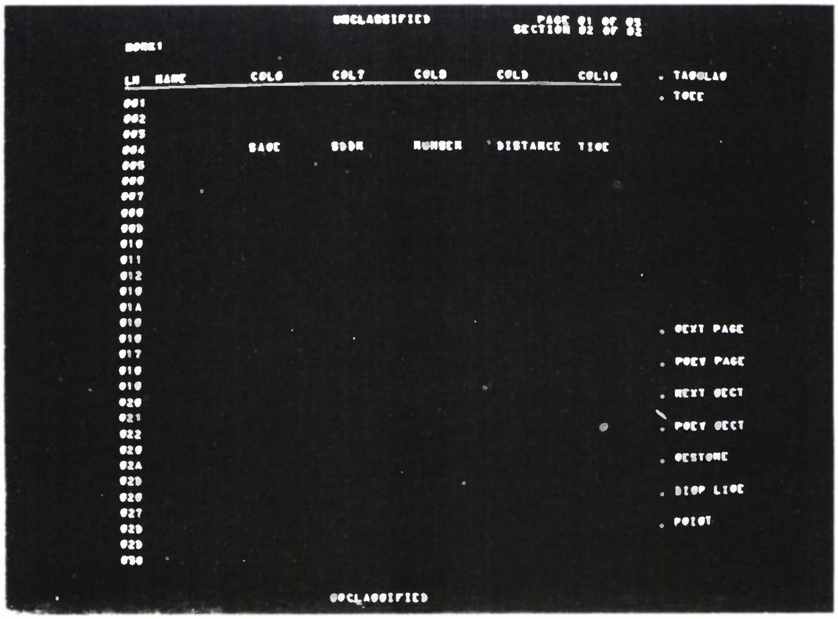


Figure 10b. Page 1 Section 2 of Same File Reserved for The Answer

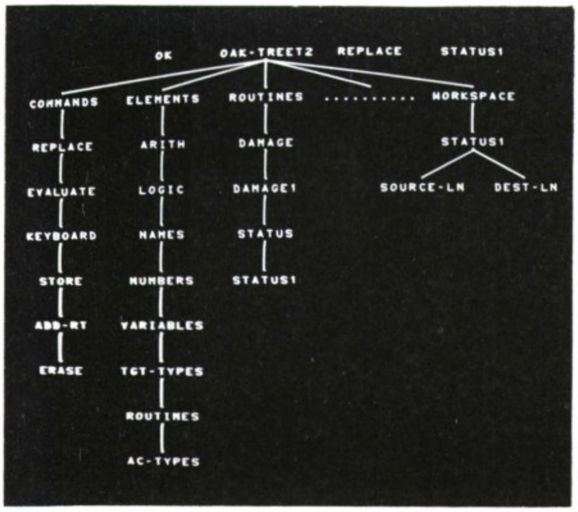


Figure 10c. Algorithm Communication Tree Showing Available Commands, Elements, and Routines

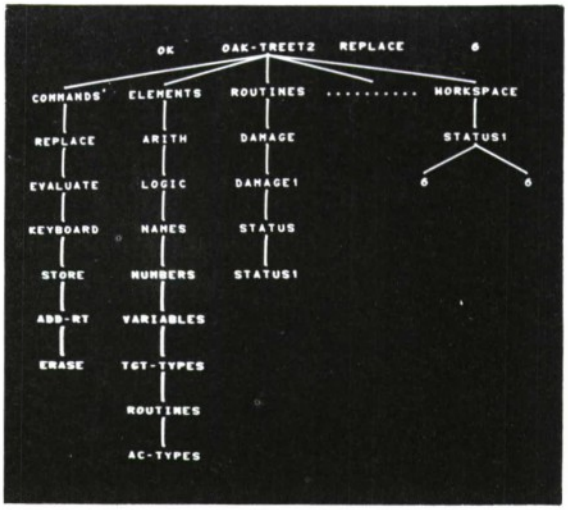


Figure 10d. Inserted Parameters To Be Used With STATUS1 Routine

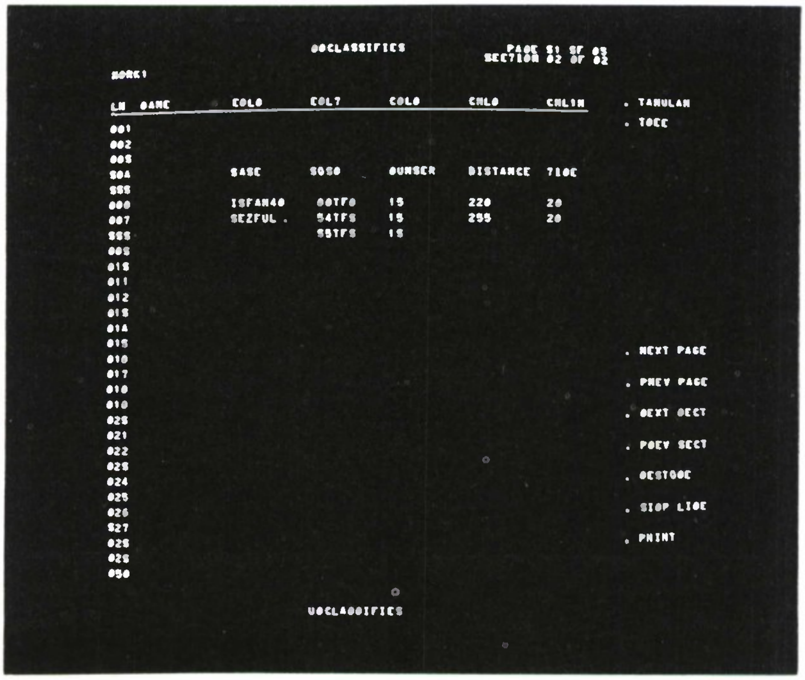
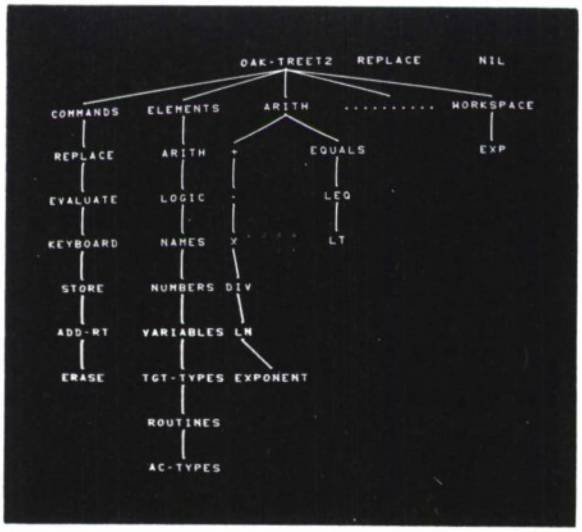
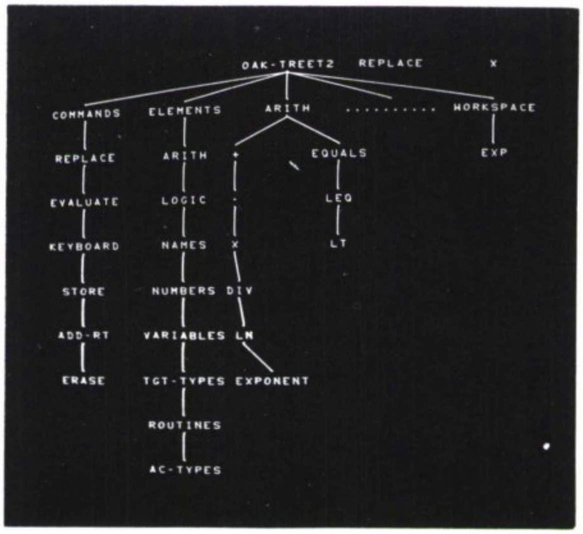


Figure 10e. Result of STATUS1

We then lightgun the ARITH operators in the elements branch. This action causes the display of all of the arithmetic operators available to the user, as shown in Figure 11a. We then lightgun the MULTIPLY symbol in the arithmetic operators, causing it to appear in the upper right of the display indicated in Figure 11b.



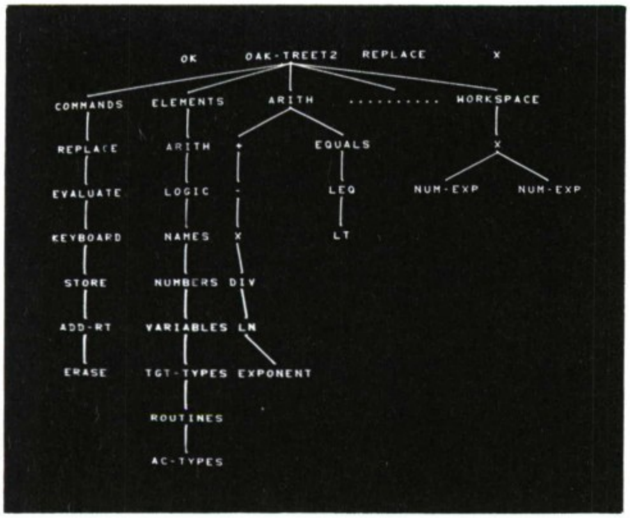
(a)



(b)

Figure 11. Steps in The On-Line Construction of a Primitive Procedure to Multiply 30 by 30.

Lightgunning the word EXP in the workspace causes two syntactic limbs to appear under the multiply sign which tell us that we must multiply at least two numeric expressions one by the other, Figure 11c. To obtain some numbers to use in the multiplication, we lightgun the word NUMBERS. The resulting display, Figure 11d, allows us to compose any number we desire by lightgunning the numerals successively from left to right. The constructed number appears under the heading on the right called RESULT.



(c)

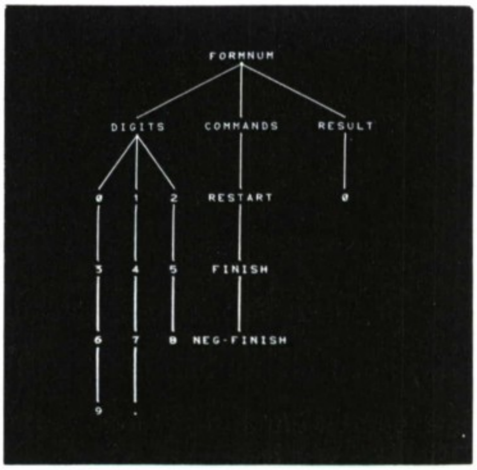
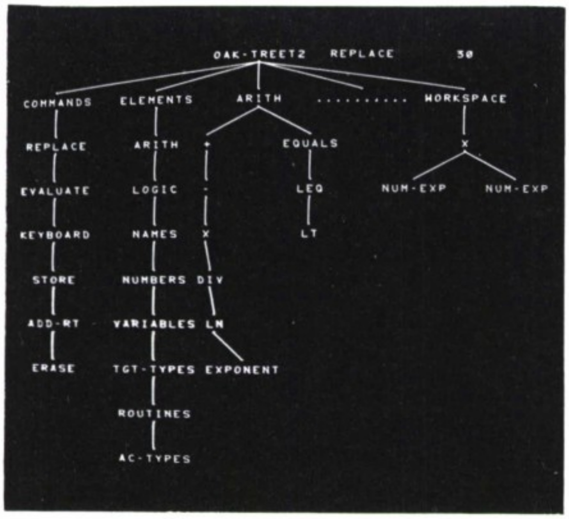


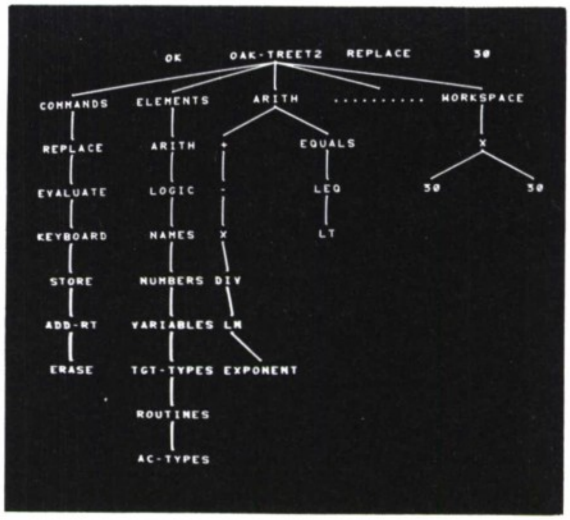
Figure 11. Cont.

(d)

The number 30 is constructed by lightgunning the numbers 3 and 0 in succession. Lightgunning FINISH returns us to our familiar display with the number we constructed in the upper right of the display, in this case 30, as shown in Figure 11e. We now have composed a complete command, REPLACE THIRTY, and we will lightgun EXPRESSION in the workspace twice. Figure 11f shows the operation or algorithm we have constructed, "multiply 30 by 30." Having constructed the simple multiplication, we lightgun the word EVALUATE, causing the answer to be printed out on the console typewriter. Figure 11g.



(e)



(f)

```
(X 30 30)
VALUF ..      900
```

(g)

Figure 11. Concl'd.

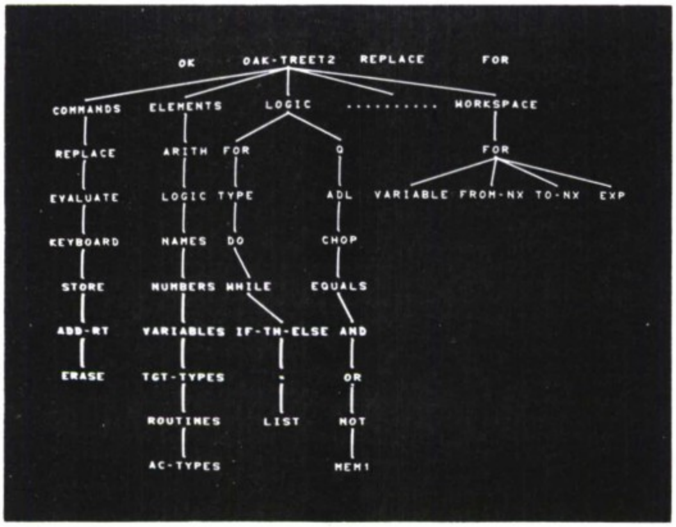
Having shown the principles of use we will now briefly illustrate a logical operation. From the set of logical operators obtained by lightgunning the word LOGIC, we lightgun the word FOR and obtain the display shown in Figure 12a. Once again let us call your attention to the fact that a syntax specification is included. In all cases, wherever an ambiguity could arise or whenever the next action requires a specialized knowledge of the syntax, the system provides this information to the user. In this particular situation, when FOR appears in the workspace it tells us that for some variable from some number to some number we will be executing some expression. From the variable list we pick C, and we will place it in the workspace. We next go to our numbers and construct the number 1. We will place this under the FROM NUMBER in the workspace. In the same way, we construct the rest of the expression until it is in the form we wish as shown in Figure 12b.

The expression now reads, "For C as it goes from one to ten type C, a spacer of four dots and C to the tenth power." We next lightgun the word EVALUATE and again the answer will appear on the console typewriter.

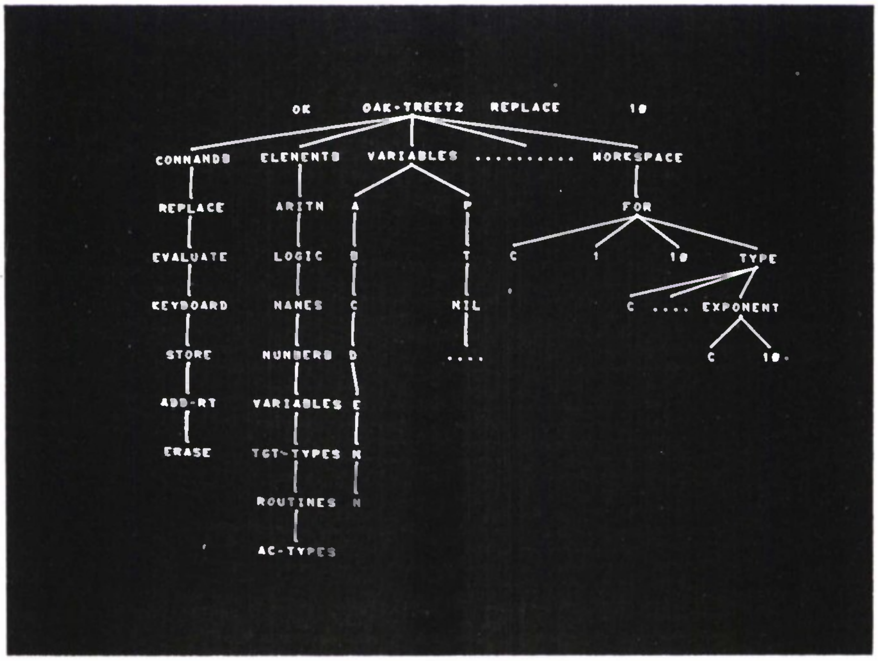
With the two capabilities just illustrated, that is, parameter insertion and analytical method construction, we have a good deal of flexibility, although not enough for real-time management systems.

Essentially, the flexibility of an on-line processing system reflects not only its ability to perform in support of many people at many levels in organization, but also to change on-line, in response to new and changing demands upon it at many different levels and places in the total organization or environment.

When AESOP, or for that matter, any on-line management system, operates in an organizational context, the users of that system have to be able to do more than develop, store, and execute their own job-oriented programs. They must



(a)



(b)

Figure 12. Steps in The Construction of a More Complex Algorithm

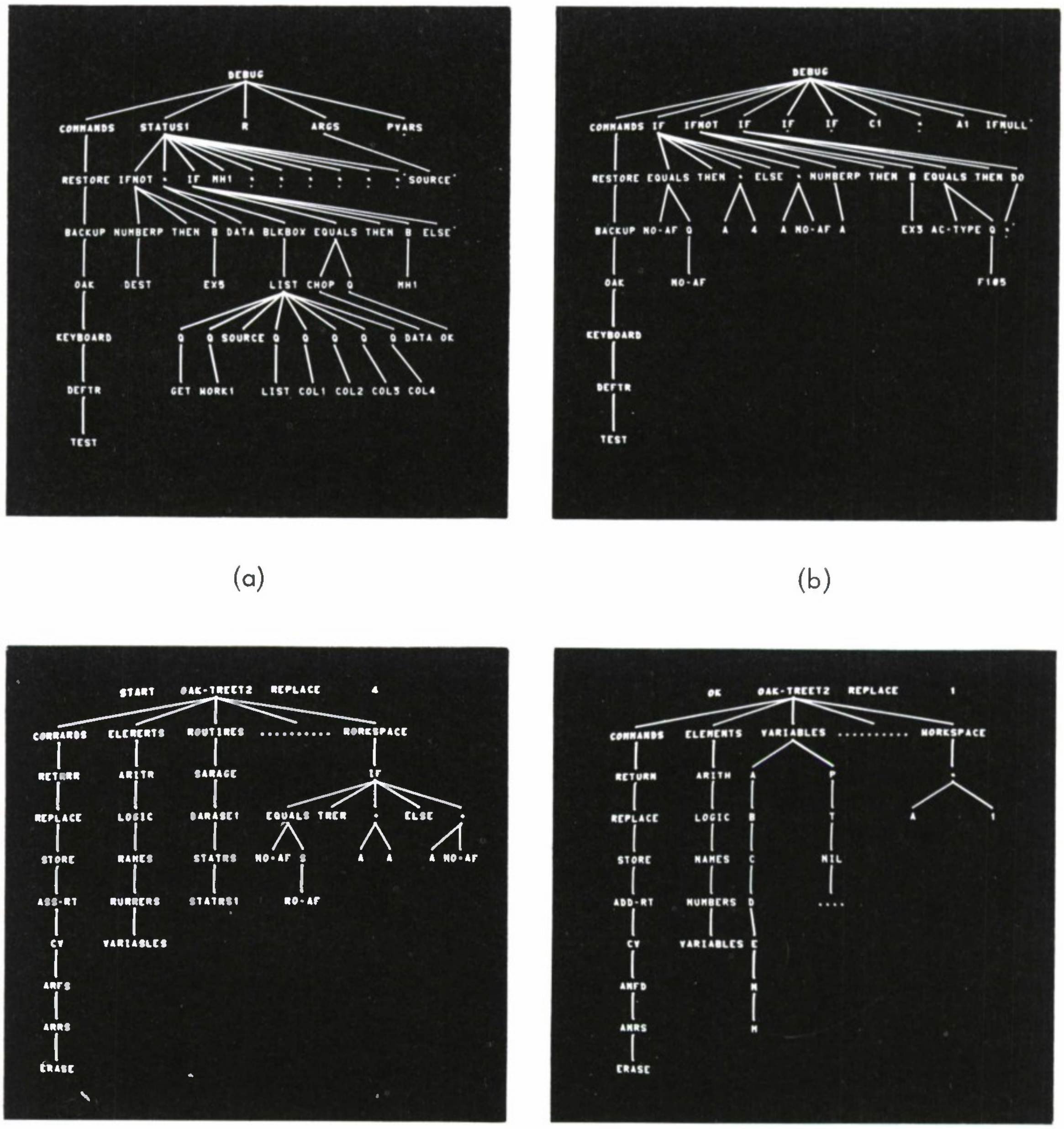
also share the common data base, the common data retrieval and updating routines, and the common on-line processing procedures designed to use this data base. At the same time, each of these users must have some ability to modify the system's performance to meet the changing needs of his job, without violating the performance of the system in support of other organizational members whose jobs do not warrant alteration of system capabilities.

The full flexibility also implies an ability of the system users to change, on-line, the performance of the system, to meet their own changing needs or wishes, while other members of the system are simultaneously using the system in its original form. This implies a design strategy by which the system enables its users to access all of its current capabilities while other users are programming and debugging these changes and modifications. In effect, the system should permit multiple copies of itself to operate simultaneously, thereby making it possible for system supervisors and organizational managers to review alternative forms of system operation in order to agree upon the acceptability of the proposed modifications and extensions.

To aid the on-line programmer faced with debugging problems or with a requirement from higher organizational levels to change given routines, the AESOP prototype has made a provision for this capability. To illustrate this capability we will change the STATUS1 routine utilized earlier, so that we get information on only the closest airfield. To do this we call up a routine called DEBUG. Figure 13a shows the routine code. Note that it is in the same familiar tree structure seen before. On the leftmost limb of the display are some commands to assist us in looking at the routine. When we wish to look through the routine, we can lightgun any node and this node is immediately brought over to the second limb of the tree. Figure 13b shows the statement that we wish to change. Lightgunning the word OAK takes what was in the secondmost limb of

the debug tree into the algorithm format explained earlier, as shown in Figure 13c. This is now available for modification and change. To modify this program we are going to delete the entire expression in the workspace and replace it with the expression A = 1. The equals tells us that some variable must be set equal to some expression. The expression we are going to use will be simply the number 1, since the variable A controls the number of airfields that are checked. Having modified the expression in the same way we built the earlier algorithms, Figure 13d, we lightgun the command RETURN and the modified expression is placed back in the second limb of the display, Figure 13e. Lightgunning RESTORE brings back the beginning of the routine. Lightgunning DEFTR redefines the routine to include the modifications. The routine can be re-exercised, this time asking that its answer be placed on line 10 rather than line 6. Figure 13f shows the output of both operations.

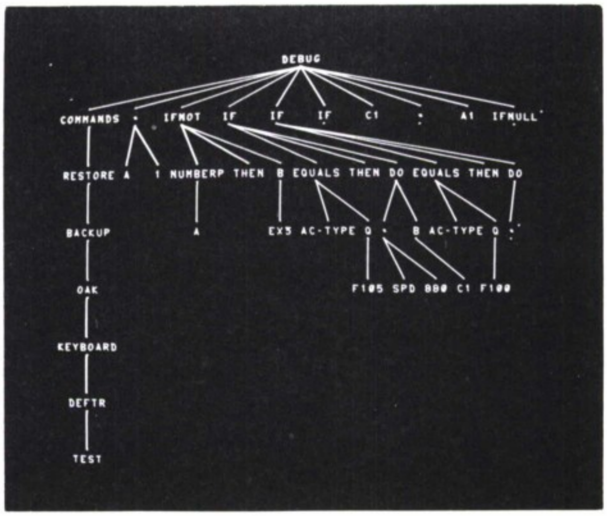
These three capabilities, parameter insertion, algorithm building, and debugging, together with the capabilities indicated earlier, constitute the AESOP Prototype system. It has something for everyone in the organizational hierarchy. It is this last "something for everyone" that we believe characterizes the management information system of the future.



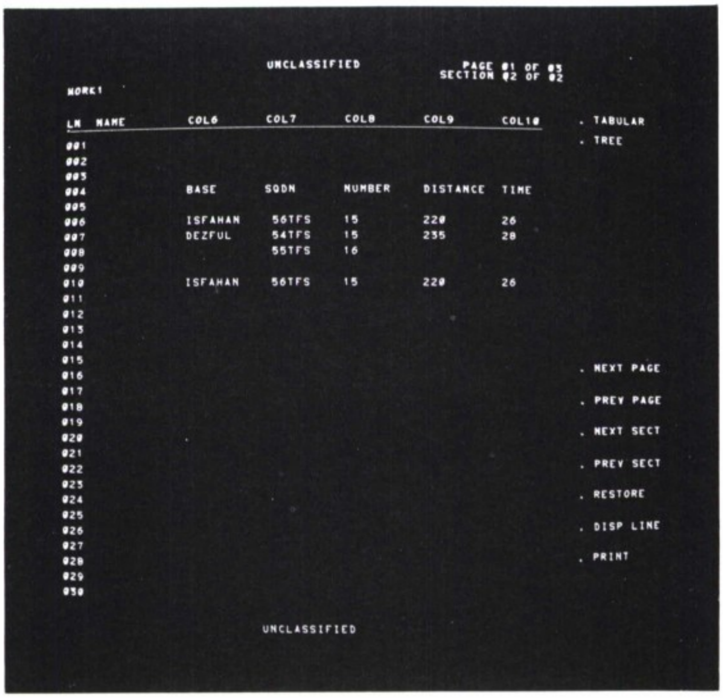
(a) (b)

(c) (d)

Figure 13. Steps in The Modification of an Interpreted System or User Procedure



(e)



(f)

Figure 13. Concl'd.

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13. ABSTRACT

AESOP, a laboratory-based prototype of a general purpose, on-line, visually-oriented information system, is used to investigate ways of handling many different types and levels of command and management problems spanning organizational levels from the executive suite down through the staff and operations analysts to the actual system designers and programmers. In particular, it deals with those organizational activities that require highly flexible, direct-access capabilities.

The system is configured for easy use by the inexperienced as well as by the sophisticated, and utilizes a variety of user station devices to facilitate such flexibility, including a cathode-ray-tube display, a lightgun, a typewriter, and associated push-buttons. At each station, it is capable of generating, editing, and formatting information on-line, as well as building, executing, and debugging on-line the analytic and mathematical procedures and algorithms of both the users and the system itself, depending upon the organizational area of level of the user. Although the basic prototype system was developed for use in military command and management planning and information systems, its philosophy and concepts are applicable to industrial and academic organizations.

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